Dräger

Heat Balance of Premature Infants

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This calculation program is only an approximation model and is not suited to select the incubator settings.

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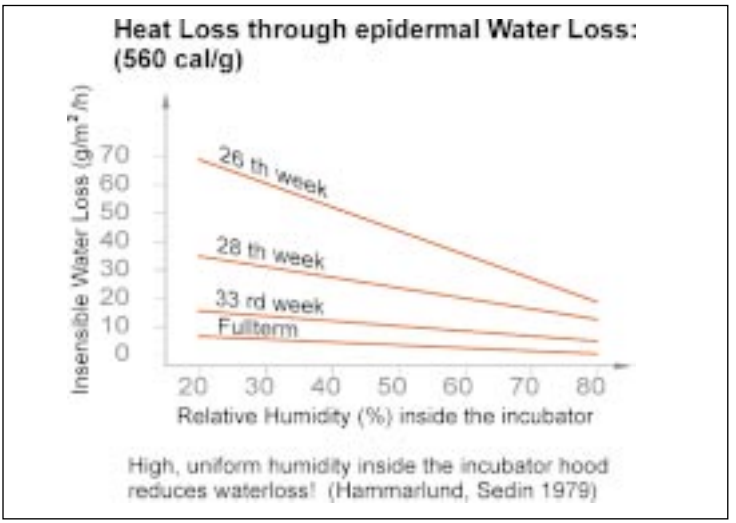
Introduction

The first paediatrician recorded in history to discover the essential influence of the body temperature on the mortality of neonates was the Frenchman Pierre Budin as early as 1907. In his book »The Nurseling« [1] he described the necessity to check temperatures. For a rectal temperature between 32.5 and 33.5 °C the neonates' survival rate was a mere 10%. When the infants were warmed to such an extent that the rectal temperature was between 36.0 to 37.0 °C the survival rate increased to 77%! It can be assumed that no other medical invention has broad similar improvements in had a similar impact on the survival rate of neonates.

In 1957, fifty years later, Silverman and Blanc [2] discovered the important influence of humidity on mortality. In 1979, Hammarlund and Sedin [3] established the correlation between transepidermal water loss and the gestational age.



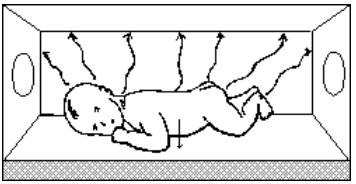
In their first days of life premature infants suffer extremely high trans-epidermal water loss due to their immature skin. In incubators with a high ambient humidity this water loss and the great circulatory stress associated with it can be significantly decreased.

Heat Balance

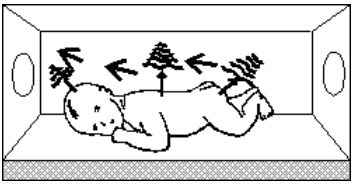
At Drägerwerk a calculation program was developed based on the physical algorithms known for heat loss and on clinical experience which can be used to calculate an approximation of the heat balance of premature infants in incubators. It shows what influences the various types of heat loss have and how incubators ensure that the infants are kept warm. In particular, the program demonstrates the significance of ambient humidity in incubators.

The calculations of the radiative and convective heat exchange were derived from the laws of physics [7]. The temperatures of the top and side walls derive from the design of the incubator and the ambient temperature [8][9]. The evaporative heat loss was calculated in accordance with publications of clinical studies [3][10][11]. Conductive heat loss is negligible for foam mattresses and is therefore not taken into account in this program. Phototherapy is another heat source, if switched on.

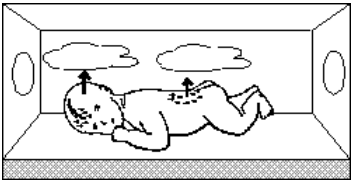
The various types of heat loss are:



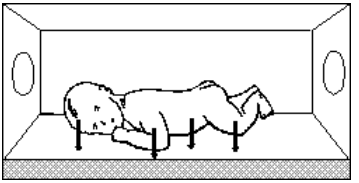
Radiation



Convection



Evaporation



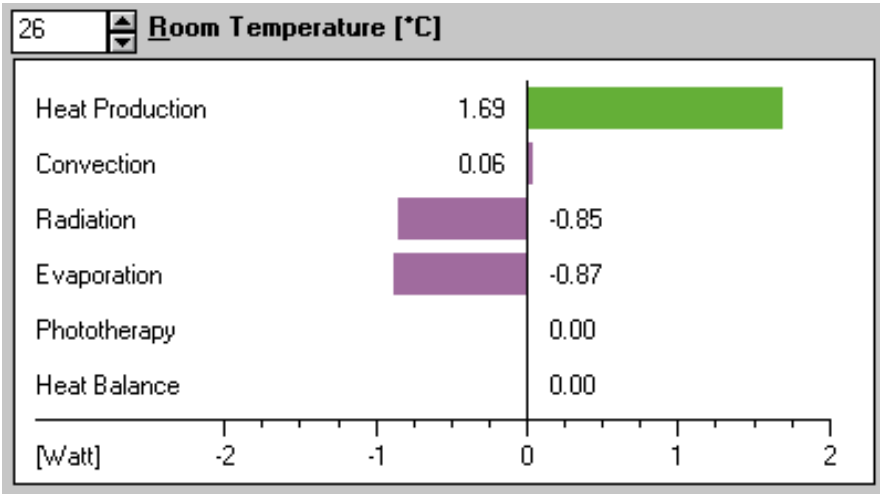
Conduction

Calculation Program »Heat Balance«

The »Heat Balance« program runs on PCs under Windows 3.x and can be operated with keyboard or mouse. The program surface consists of:
– input area for patient data,
– Incubator settings and
– result field.

The patient is presented by the following data: The patient data is the basis for the approximation to determine the body surface [4] and the heat production [5][6] of the infant.

The result field contains the calculated results represented as bar graphs and numerals. All results are stated in »Watts«. On the right hand side of the center line the heat production of or heat supply to the infant is displayed as the positive range and the heat loss is displayed on the left hand side of the center line. The length of the bars show the portion of the relevant type.

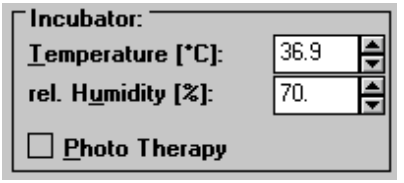


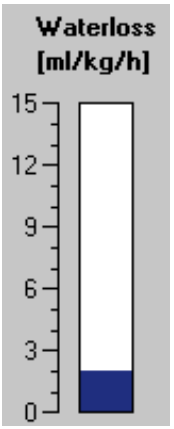
The ambient temperature is an important parameter influencing the thermal behaviour of incubators and must be stated for the calculations.

The bottom bar shows the heat balance as the result of the calculations. The baby is thermally balanced when the sum of all types of heat loss equals the baby's heat production.

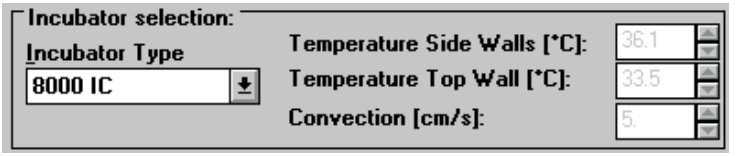
If the result of the balance is
near zero: The baby is thermally balanced
negative: The temperature or humidity is too low. The baby cools down (hypothermia)
positive: The temperature or humidity is too high. The baby gets too hot.(hyperthermia, fever)

The incubator temperature and humidity are adjusted to such values that the balance will preferably be close to zero.

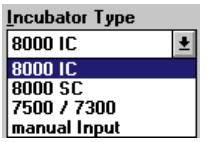




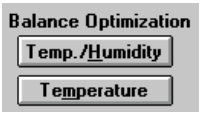
To the right of the result field a bar graph shows the water loss [3][10][11] in ml/kg/h. When the value exceeds 6 ml/kg/h the bar colour changes from blue to red. In that case the water loss of the infant is so high that it requires parenteral water supply [10]. In order to avoid the enormous circulatory stress associated with the water supply the incubator humidity should be set to a value where the water loss does not exceed 6 ml/kg/h.



In the field »Incubator selection« the various Dräger Incubator types can be selected for calculation. The selection »manual input« allows calculations with incubators from other manufacturers. The values for the temperature of the top and side walls as well as the convection rate around the infant are preset parameters in Dräger Incubators and cannot be changed. These parameters are activated when »manual input« has been selected and must be adjusted in accordance with the relevant type of incubator.

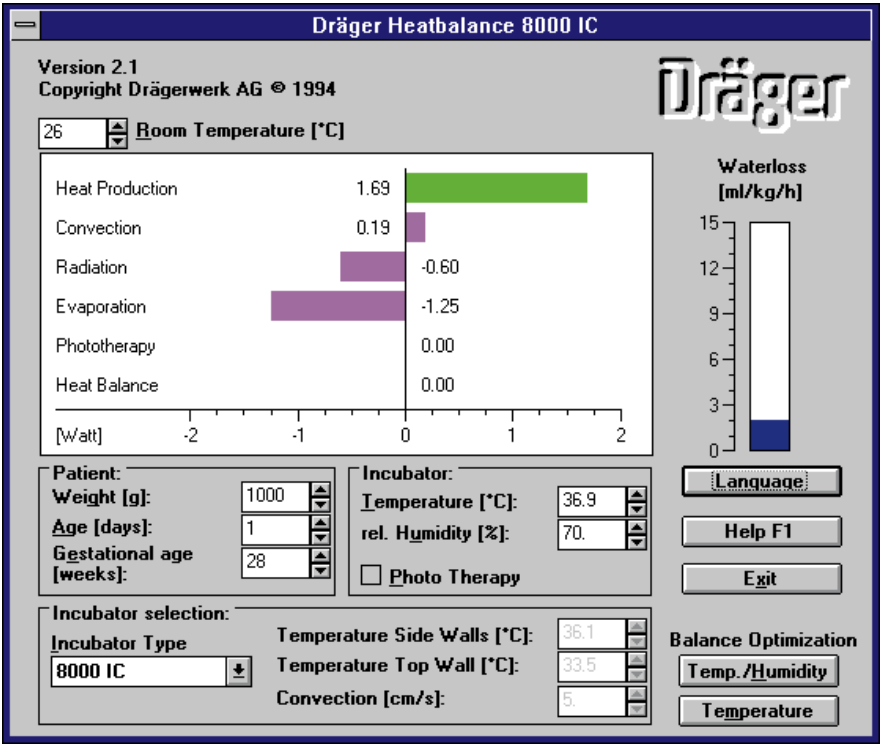


The »Language« key serves to select from among the languages German, English and French. The help system comprises a comprehensive program description, the physiological background to warmingtherapy as well as the algorithms used including references. With »Exit« you can exit the program.



After pressing the »Temp/Humidity« key the program runs an automatic search for the Incubator temperature and humidity settings at which the balance approaches zero. With the »Temperature« key the Incubator temperature can be changed while the humidity setting remains the same.

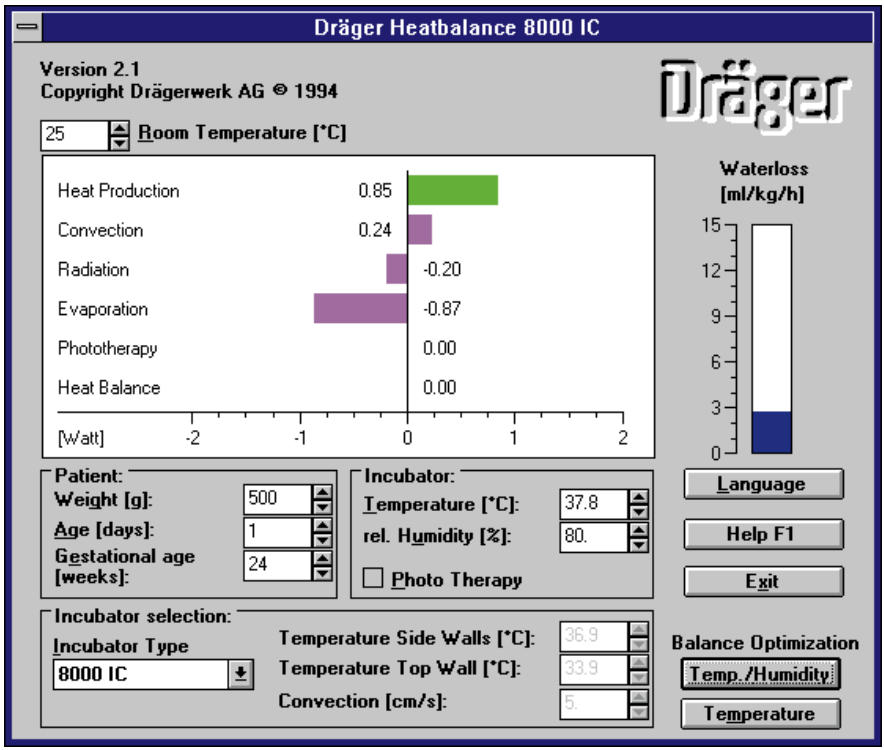
The individual function fields make up the following overall display:



Sample Calculations
Baby Weighing 1000 g Nursed in an Incubator 8000 IC
With these settings the baby is in thermally neutral conditions, i.e. heat production and heat loss are balanced.

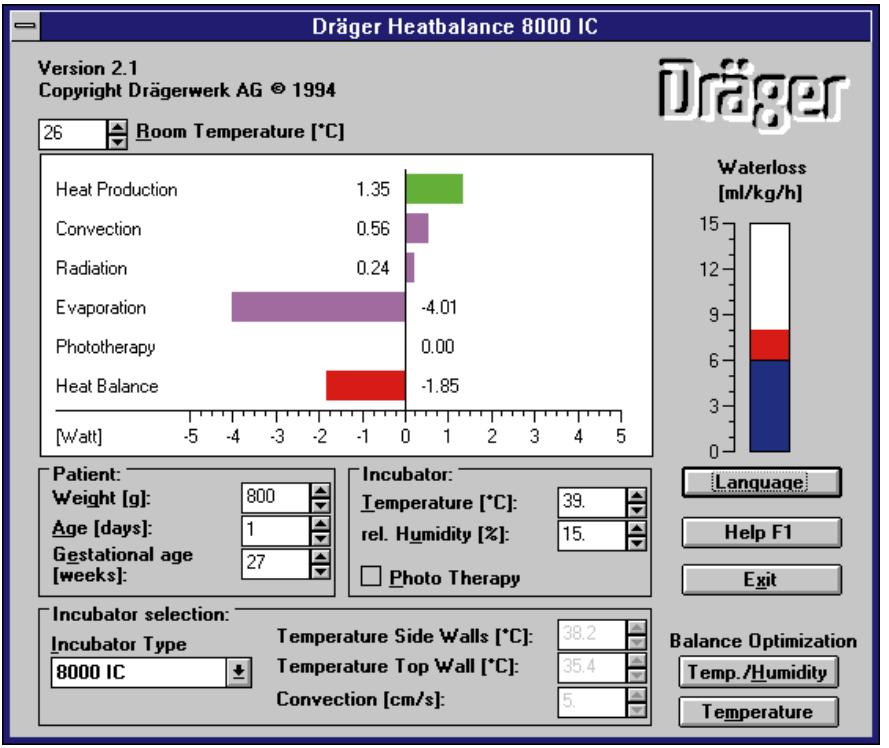
Extremely Small Premature Baby

Even the smallest premature babies can be kept in thermally neutral conditions. The maximum incubator temperature is 39 °C (International Standard IEC 601-2-19.). The very efficient humidification in incubators ensures that heat loss and water loss are compensated for.



Incubators without Humidification
In incubators which are not humidifying the air the relative humidity is extremely low (down to 15% relative humidity depending on the ambient humidity and the incubator temperature). There is no heat balance. The baby will cool down and suffers heat loss (in this case 1.85 Watts and the water loss will be 8 ml/kg/h)!

Consequently, it is impossible to keep immature preterm babies warm in incubators not provided with an adequate humidification.



Our sales engineer will be pleased to show you this program on one of his next calls.

References

[1] Pierre Budin »The Nurseling« 1907

[2] Silverman und Blanc »The effect of humidity on survival of newly born premature infants« 1957

[3] Hammarlund, K., Sedin, G.,: Transepidermal water loss in newborn infants, III. Relation to gestational age, in: Acta Paeatr. Scand. 68, 795, (1979)

[4] Boyd, E.: The groth in surface area of the human body. Univerity of Minesota Press (1935)

[5] Brück, K.: Wärmehaushalt und Temperaturregelung, in: Physiologie des Menschen, Schmidt, R. F., Thews, G., (Hrsg.), 21. Auflage, S. 583 ff., Berlin, Heidelberg, New York (1983)

[6] Brück, K.: Temperature regulation in the newborn infant in: Biol. Neonat. 3, 65, (1961)

[7] Frankenberger, H., Güthe, A., Inkubatoren Verlag TÜV Rheinland (1991)

[8] Drägerwerk Lübeck: Laboratory-Measurements 1 on Incubator 8000 IC/SC (1992)

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[10] Hammarlund, K., Sedin, G.,Strömberg, B.: Transepidermal water loss in newborn infants, VIII. Relation to gestational age and post-natal age in appropriate and small for gestational age, in: Acta Paeatr. Scand. 72, 721, (1983)

[11] Okken, A.; Blijham, C.; Franz, W.; Bohn, E.,: Effects of forced convection of heated air on insensible water loss and heat loss in preterm infants in incubators, in: The Journal of Pediatrics 101, 108, (1982)

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